CARIBOO FOREST REGION RESEARCH SECTION

Extension Note

"Making Research Work for You"

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RESEARCH ISSUE GROUPS

- Soil Conservation
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Cariboo Forest Region, BC

Itcha – Ilgachuz Alternative Silvicultural Systems Project: Microclimate, Planted Stock and Natural Regeneration

INTRODUCTION

This project was developed to address the challenge of extracting commercial timber from the Montane Spruce (MS) and Sub-Boreal Pine–Spruce (SBPS) zones in the west central interior of B.C., while maintaining suitable habitat for populations of northern caribou, an ecotype of woodland caribou (*Rangifer tarandus caribou*).

Within the Cariboo Forest Region, northern caribou are considered a key management species. Under the Cariboo-Chilcotin Land Use Plan (a higher level plan under the Forest Practices Code), about 20% (202,000 ha) of caribou habitat will become available for timber extraction using "modified harvesting" practices. In winter, caribou feed primarily on terrestrial and arboreal lichens in low elevation forests in the MS and SBPS zones. Caribou prefer mature and old lodgepole pine (*Pinus contorta*) forests with abundant terrestrial lichen and low snow depth for easy cratering. Caribou also seek out mature to older spruce (*Picea engelmannii* x *glauca*) and pine stands, often adjacent to wetlands and meadows, where arboreal lichen is concentrated.

Clearcutting is the standard silvicultural system for lodgepole pine forests. Harvesting removes the arboreal lichen and, without a substantial snow pack, may physically damage the terrestrial lichen. The terrestrial lichen can also be damaged by site preparation techniques and by changes in microclimate. Removal of the overstory canopy allows increased light and frost frequency, as well as extreme fluctuations in humidity and temperature. Lichen dispersal, establishment, and growth are slow and it may take many decades before the quantity of terrestrial lichen within a clearcut is comparable to old stands. Even more time is required to restore arboreal lichen biomass.

For these reasons, alternative silvicultural systems are being tested for their effectiveness in reducing the impact of harvesting on caribou habitat, particularly on important lichen forage species. Before the alternative silvicultural systems are recommended, other issues such as

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tree regeneration, windthrow, wildlife diversity, tree insects and diseases and long-term productivity must also be investigated. This research project provides the opportunity to study each component relative to the others and will result in an integrated resource management solution.

OBJECTIVES

This extension note describes third and fourth year results regarding short-term impact of group selection and irregular group shelterwood silvicultural systems, using whole-tree and stem-only harvesting methods, on:

- micro-climate
- survival and growth of planted lodgepole pine and hybrid white spruce seedlings; and
- natural regeneration ingress rate

SITE DESCRIPTION AND CLASSIFICATION

Five harvest blocks were selected from Riverside Forest Products Ltd. development area south of Punkutlaenkut Creek in the West Chilcotin. The blocks are on a gently rolling, high elevation plateau near Satah Mountain (52°28'N, 124° 43'W), about 12 km south of the summit of the Itcha Range. The two lowest elevation blocks (1320 and 1360 m) are in the SubBoreal Pine - Spruce Very Dry Cold (SBPSxc) Subzone while the three higher elevation blocks (1430, 1520, and 1640 m) are in the Montane Spruce Very Dry, Very Cold (MSxv) Subzone. The stands in these blocks are even-aged, single-layered lodgepole pine stands, typical of these two subzones. No other tree species are found on the SBPS blocks, but a few hybrid white spruce and subalpine fir occur on the MS blocks. Undergrowth vegetation is low-growing and dominated by kinnikinnick (*Arctostaphylos uva-ursi*), lichens, and patches of pinegrass (*Calamagrostis rubescens*). Relatively few vascular species occur, but a rich variety of lichens, primarily *Cladonia* species, are present. The undergrowth vegetation on MSxv zonal sites is dominated by crowberry (*Empetrum nigrum*), grouseberry (*Vaccinium scoparium*), mosses, and lichens.

EXPERIMENTAL DESIGN AND TREATMENTS

The experimental design is a randomized block. Each of five harvest blocks was divided into four, approximately equal-sized treatment units (about 15 ha each). Three harvesting treatments (described below) and an unlogged control were randomly assigned to the four treatment units within each block. Clearcuts, adjacent to the trial blocks, were included in the planted stock trial and microclimate monitoring project. Harvesting was done in winter to reduce physical damage to the lichen. Harvesting on all blocks began in January 1996 and was completed in April.

Treatments 1 (T1) and 2 (T2) are irregular group shelterwood silvicultural systems where the target area removal was 50% in small openings 20–30 m in diameter. The residual stand provides shelter for terrestrial lichen. The two treatments differ by method of harvest:

- Treatment 1 (T1): Stem Only Harvesting (SOH). Trees were felled and piled using a feller-buncher. The trees were delimbed, topped, and cut-to-length at the stump with a processor, then moved to roadside by a forwarder. Slash was piled to minimize the amount of lichen covered and maximize the number of plantable spots. This treatment has considerably more slash in the openings than Treatment 2.

- Treatment 2 (T2): Whole Tree Harvesting (WTH). Trees were harvested using conventional equipment and methods (feller-buncher, grapple skidder, and roadside processing). Roadside processing involved delimbing, piling and burning the debris. Terrestrial lichens could be disturbed by skidding of whole trees to roadside. Also 3–7% of the treatment unit is occupied by a right-of-way processing area; however, less slash is left in the openings to affect terrestrial lichens and there are a wider range of planting sites.

Treatment 3 (T3): Stem Only Harvesting (SOH). This is a group selection silvicultural system treatment based on a 33% area removal in 15 m diameter openings. This treatment was harvested using

the system described for Treatment 1.
These study blocks will be managed on a longer rotation than is currently used for lodgepole pine (80 years) or spruce (120 years). On the irregular group shelterwood units (T1 and T2), the second 50% of the block will be harvested in approximately 70 years. The first 50% of the block is expected to be ready for second harvest in 140 years. For the group selection treatment (T3), the cutting cycle is 80 years, at which time a further 33% of the area will be harvested. The first 33% of the block is expected to be ready for a second harvest after 240 years.

STAND DESCRIPTION

All blocks associated with this trial have no previous management history. All stands were likely initiated after stand-destroying wildfires between 160 and 220 years ago. Lodgepole pine regeneration after wildfire in these subzones is typically rapid and not affected by competing shrub and herbaceous vegetation. The resulting stands are mostly even-aged and single-layered. General dryness of the sites and periodic mortality due to mountain pine beetle result in moderately open stands in the SBPSxc. Patches of young pine regeneration are common in these stands, although they rarely reach into the main canopy. In the MSxv, fewer trees are killed by mountain pine beetle so stands tend to be more closed and clearly single-layered, with little natural regeneration beneath the canopy.

MICROCLIMATE

Microclimate has a very strong effect on survival, condition and growth of seedlings in the MS and SBPS zones. Six climate stations were set up, starting in 1997, in blocks 1, 3 and 5. Soil and air temperature profiles (15 cm soil, 1 cm soil and 15 cm air) were measured in three openings (one per block) in the 50% WTH treatment and three adjacent clearcuts. The centre, south and north edges of each opening were measured while in the clearcuts two profiles, 10 m apart, were monitored. Data presented in Table 1 are based on the mean of the profiles by block and treatment.
The study blocks are harsh growing sites for trees because of frequent growing season frosts. In the clearcuts, 49% of the nights have average temperatures below 0°C compared to 37% in the partial cuts. Frosts, sufficiently severe to cause significant tissue damage (-4°C), also commonly occur on the clearcuts (18% of the nights). This was reduced to 5% in the partial cuts. Growing degree days (measure of available heat for metabolism) and July soil temperatures indicate that soils in the clearcuts are warmer than the partial cuts in all blocks and all years. Within the openings the centre and sunny edges are 1-2 °C warmer than the shady edges. The soil data from 1999 and 2000 shows that block 5, the highest elevation block, is cooler than either block 1 or 3. Data from 1998, a low snow year, found that the soil in the rooting zone dropped below freezing (down to -3°C) for most of the winter in all blocks and both treatments. This could cause root damage and therefore affect seedling performance. In the deep snowpack year (1999) the soil remained closer to 0°C due to the insulating effect of the snow. The soils on these research sites are colder than those documented in the IDF, ICH and SBS in the Cariboo Region, perhaps resulting in slower tree growth rates.

Microclimate Summary

The number of severe frost events is greatly reduced in the partial cuts compared to the clearcuts. However, shading within the openings causes cooler soil temperatures especially on the shady edges. The cooler soils in block 5 may reduce tree growth especially in the partial cut. Years with low snowfall increase the risk of ground freezing and root damage.

PLANTED STOCK

The trial plots were spring planted in 1997 with the following stock types: PSB 415B SX 1 + 0 and PCT 415B PL 1 + 0. A total of 4,694 trees were planted in the five blocks. In treatments, T1, T2 and clearcut there are 6 plots each containing 41 trees while in T3 there is 10 plots containing 25 trees. The plots were paired within each treatment unit based on species.

Survival and condition

Survival of seedlings was compared between treatments. Survival of spruce was lower

Table 1. Summary of microclimate data recorded in clearcuts (CC) and partial cuts (PC)

Year	Subzone	Elev. (m)	Block	Treatment	Sample period	Min. 15 cm air temperature		Average 15 cm soil temperature	
						No. of nights		Growing degree days	July
						(<0°C)	(<-4°C)	(>5°C)	(°C)
1997	SBPSxc	1290	1	CC	June 5 – Sept 24	74	26	648	11.8
				PC	(112 days)	51	12	545	11.3
	MSxv	1420	3	CC		53	12	656	11.8
				PC		34	5	472	10.0
1998	SBPSxc	1290	1	CC	May 1 – July 31	40	15	544	14.5
				PC	(92 days)	32	4	495	13.8
	MSxv	1420	3	CC		29	6	533	14.3
				PC		23	2	413	12.5
1999	SBPSxc	1290	1	CC	June1 – Sept 16	56	28	621	11.4
				PC	(108 days)	45	12	600	11.2
	MSxv	1420	3	CC		43	13	648	11.4
				PC		34	3	509	10.1
	MSxv	1620	5	CC		54	21	451	10.5
				PC		38	7	401	9.2
2000	SBPSxc	1290	1	CC	June 1 – Sept 13	57	33	654	12.5
				PC	(105 days)	44	8	573	11.8
	MSxv	1420	3	CC		52	10	625	12.2
				PC		41	1	470	10.7
	MSxv	1620	5	CC		60	21	518	11.4
				PC		44	2	350	9.4

overall in the clearcuts (76%) than in all partially cut treatments (90-93%) (Fig. 1). Spruce survival was highly variable between clearcuts, ranging from 40% in block 5 to 98% in block 3. Survival of pine was similar between partial cuts and clearcuts (93 – 96%). Comparisons were also made between the treatments based on condition (good, fair, or poor). The proportion of pine in each condition class did not vary by treatment but spruce trees in the 50% harvest treatments were more likely to be in good condition (43%) compared to either the clearcuts (18%) or 30% harvest treatment (28%).

Condition was examined in more detail by looking at the stem, foliage and leaders of the seedlings. Stems were healthy (>87%) but the foliage and leaders, especially on the spruce trees showed environmental stress. The spruce foliage was chlorotic on 16-21% of seedlings in the clearcuts and 50% partial cuts, while it averaged 33% in the 30% treatment. Also, a large proportion of the spruce seedlings had dead buds due to frost in the clearcuts (40%); however, this was reduced in the partial cuts (10-13%). In contrast, the foliage was generally healthy (73-76%) for the lodgepole pine planted in all treatments. For spruce, 73-78%

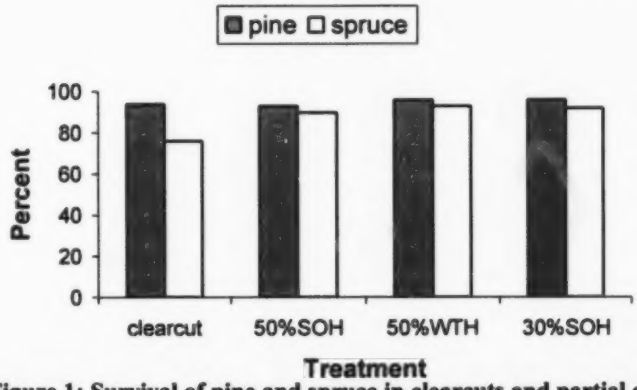

Figure 1: Survival of pine and spruce in clearcuts and partial cuts four years after planting

of the leaders were rated healthy regardless of partial cutting treatment; however, only 48% were healthy in the clearcuts. In the clearcuts, there was a high proportion of terminals that were dead (43%) due to frost. In the partial cuts, there were also dead terminals (7-13%). In contrast, more than 82% of the pine trees had healthy leaders in the partial cuts and 76% in the clearcuts. Ungulate browsing was noticeable in all treatment units, especially on the pine (6-11%).

Height and ground level diameter growth

Accumulated height and diameter growth of the seedlings, from 1997 - 2000, are summarized by treatment in Table 2. At the end of the fourth growing season, height growth of spruce was significantly greater in the three partially cut treatments than in the clearcuts while growth of pine was not significantly different. Spruce diameter growth was marginally different among treatments due to less growth in the 30% SOH treatment compared to all other treatments. The ground level diameter of pine was significantly larger in the clearcuts compared to all partial cuts. There are no significant differences between treatments for the leader growth of pine in 2000 (5 – 7 cm), or for spruce leader growth (4 – 6 cm) (Table 2). Total height and total diameter of the seedlings follows the same pattern as for growth. Based on the fourth year leader length, pine will reach the free-growing height requirement in the MS (1.0 m) by 15 years in all treatments but this is less likely in the SBPS where the height requirement is 1.4 m, unless the growth rate accelerates. Spruce is expected to reach the free-growing height requirement of 0.8 m in both subzones.

Planted Stock Summary

1. For pine, the method of partial harvesting (SOH or WTH) and amount harvested, have not affected survival or condition. The height growth of planted pine is similar between the partial cuts and clearcuts, although partial shading from the surrounding stand is causing some etiolation of the seedlings. Diameter growth is better in the clearcuts, but is not unreasonable in the partial cuts. Based on current data, all treatments are successfully regenerating; however, there is some concern that the free-growing height requirement of 1.4 m at 15 years in the SBPS may not be met unless the growth rate accelerates in all treatments.

2. To date, spruce survival and growth are variable in the clearcuts. Survival and growth are poor due to frost on blocks that are very flat. Damage due to frost is much lower in the partially cut treatments in all blocks. There is some indication that spruce is growing more and the condition is better in the 50% harvest treatments compared to the 30% harvest treatments, perhaps due to better light conditions.

Table 2. Analysis of variance models and treatment means (least square) for: total height growth (2000 height – planting height), leader length (2000), total diameter growth (2000 diameter – planting diameter) and annual diameter growth (2000) of live seedlings. Treatment means with dissimilar letters are significantly different at a=.05.

Species	Variable (cm)	Treatment means				p
		T1 - 50% SOH	T2 - 50% WTH	T3 - 30% SOH	Clearcut	
Pine	Height growth 4 yrs	19.7	20.3	18.7	16.5	.36
	Leader length	6.7	6.9	5.4	6.8	.30
	Diameter growth 4 yrs	.28[b]	.30[b]	.23[b]	.46[a]	**.0001**
	Diameter growth 1 yr	.08[b]	.09[b]	.06[b]	.20[a]	**.0005**
Spruce	Height growth 4 yrs	17.5[b]	20.2[b]	15.0[b]	9.9[a]	**.003**
	Leader length	5.3	5.7	3.7	3.6	.16
	Diameter growth 4 yrs	.32	.37	.25	.36	.06
	Diameter growth 1 yr	.09	.10	.06	.12	.21

3. The chlorotic foliage on the spruce seedlings, especially in the SBPS blocks and 30% stem-only-harvesting treatments, indicate an inability of the trees to obtain adequate nutrition. Poor root development, lack of nutrients in the soil, or dry conditions inhibiting the movement of nutrients to the roots could all be responsible for this condition.

To conclude, in caribou habitat, partially harvested blocks should be regenerated mostly with lodgepole pine. Spruce could be planted on shady south edges, wet microsites, or on edges where mistletoe is a concern. Sites originally dominated by pine should not be converted to spruce since the consequences to terrestrial lichen production (caribou forage) are unknown.

NATURAL REGENERATION

Until recently, clearcut blocks in both the MS and SBPS zones were most often left for natural regeneration following harvesting. This is still the case in the SBPS, but currently in the MS blocks are typically planted to ensure adequate stocking and shorten the time to free growing status. The objectives of the natural regeneration studies are to test whether natural regeneration will adequately restock partially cut stands and to assess the effects of the harvesting treatments and biogeoclimatic unit on natural regeneration.

In order for natural regeneration to be successful there must be sufficient seed, adequate germination, and survival of germinants. Three studies have been undertaken to evaluate the potential for natural regeneration: seed input following tree harvesting, the continuation of seed rain after harvesting, and the rate of natural regeneration ingress.

Input of seed following harvesting

In order to determine if there were differences in seed densities related to harvesting method, cones were collected from 20 – 0.5m² plots (one per opening) in T1 (50% SOH) and T2 (50% WTH) treatment units in blocks 1, 3, and 5. A subsample of cones was opened and the seed was counted and cut to determine the number of filled (potentially viable) seeds per cone.

The literature suggests that serotinous lodgepole pine cones on the ground after harvesting will open quicker and more completely than cones elevated above the ground, due to differences in warming. The amount of filled seed on the ground in serotinous cones was much greater after whole tree harvesting (2.8 M seeds/ha) than after stem only harvesting (905,000 seeds/ha). For both treatments however, most (>85%) of the cones are elevated in slash piles either at the roadside (whole tree harvesting), or in the harvested openings (stem only harvesting), rather than on the ground. Skidding of whole trees to the roadside leaves numerous cones on the ground, but the majority are piled in slash at the roadside and later burned. With stem only harvesting, slash remains on site potentially making far more seed available (up to 23.1 M seeds/ha if all of the cones opened). However, the amount of slash and the position of cones within the slash may restrict the amount of seed released and the availability of suitable seedbeds.

In blocks 1 and 3 more than 86% of the cones on the ground had released their seed by September of 1996, one growing season after harvest. In block 5, release of seed from cones on the ground was lower (46%) than in blocks 1 or 3, possibly due to the cooler temperatures. Across all blocks, seed release from cones in elevated slash (20-60 cm above ground) ranged from 13 –35% and averaged 24%. Release from cones attached to branches on the ground ranged from 40% (lower side of branch) to 73% (upper side of branch). Seed from elevated slash is less likely to land on a suitable seedbed than is seed that falls from cones on branches, or from individual cones on the ground.

The effect of opening size on seed release was compared between the 30% SOH (15 m diameter openings) and the 50% SOH (26 m diameter openings) using class 1 cones (new, closed). By the end of September, there were no apparent differences between treatments for the amount of seed released from cones whether on the ground, on branches, or in elevated slash.

Seed rain

The majority of lodgepole pine seed is found in serotinous

cones; however, a portion is released annually from non-serotinous cones. From 1997-1999, seed rain from residual trees on block 3 was monitored using 10 traps in each of the following treatment units: unharvested control, 30% SOH and 50% SOH. In the harvested treatments, traps were placed in the harvested openings. Seed was removed in May of each year, then counted and cut to determine the number of filled seed. Seed rain varied between years from a low of 47,000 seeds/ha in 1997 to a high of 137,000 seeds per ha in 1998. The amount of filled seed changed annually, ranging from 42 – 60 %. The proportion of filled seed generally increased with the size of the seed crop. Figure 2 shows no consistent difference between the treatments over the years.

Ingress

This study was designed to evaluate natural regeneration densities within openings in the various harvesting treatments and to test whether differences are related to harvesting treatment or biogeoclimatic zone.

The number of seedlings under 130 cm tall were monitored from 1996 to 1999 in permanent sample plots located in all blocks and harvested treatments. Monitoring will continue for several more years. About 50 – 2 m² plots were established prior to harvest in each treatment unit. Following harvest, regeneration was monitored in 188 plots located completely within openings; sample size ranged from 8 to 17 plots per treatment unit. The number of seedlings were tallied in each of the following age/size classes by species: < 1 year, > 1 year but < 10 cm tall, and > 10 cm but < 130 cm tall. Data were compared to regeneration ingress data that were collected previously from clearcuts in the MS and SBPS.

Third year data indicate that seedling densities were consistently higher on blocks in the SBPS than in the MS zone regardless of treatment. Regeneration densities were similar in the 50% SOH and 50% WTH treatments in both biogeoclimatic units. In the SBPS zone, seedling densities were similar in the 50% SOH (26 m diameter openings) and 30% SOH (15 m diameter openings) units despite differences in opening size. In the MS zone however, densities were substantially lower in the 30% SOH, indicating that natural regeneration at high elevations may be slow in small openings.

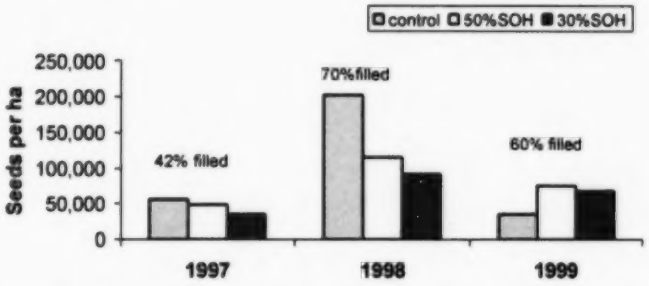

Figure 2: Annual seed rain in block 3 treatments (control, 50%SOH, 30%SOH)

Regeneration densities in these partial harvest treatments were similar to third year regeneration densities recorded previously in clearcuts in the MS and SBPS zones (Fig. 3). However, densities of germinants < 1 year old is greater than in the clearcuts of the same age, indicating that seed rain from adjacent residual trees may continue to increase seedling densities beyond that typical of clearcuts.

Natural Regeneration

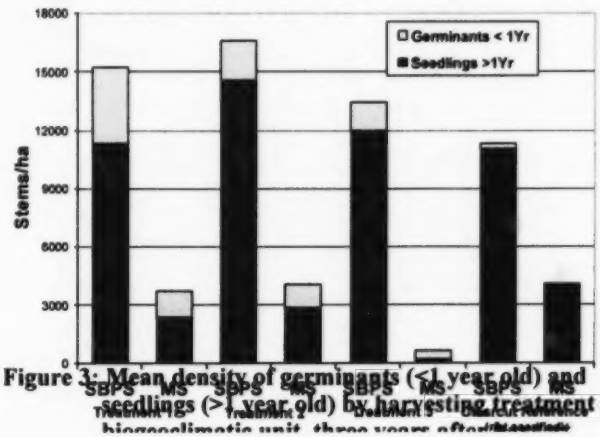

Figure 3: Mean density of germinants (<1 year old) and seedlings (>1 year old) by harvesting treatment and

Summary

1. Both methods of harvesting (stem only and whole tree) leave many seed-bearing cones on the ground to initiate a new stand. Although the number of cones on the ground is higher in the WTH treatment (treatment 2), more cones are left on site in the slash (piles and on branches) in the stem-only harvesting treatment (treatments 1 and 3).

2. Opening size did not affect the amount of seed released; however, fewer cones on the ground opened in block 5. Microclimate data indicate that block 5 is cooler than other blocks (1 and 3) where temperatures were recorded.

3. Non-serotinous cones on adjacent residual trees supply an annual rain of seed onto the harvested openings to initiate new germinants.

4. Based on third year data, natural regeneration densities are similar to those recorded after three years in clearcuts. It appears that adequate stocking will likely be achieved in the SBPS and in larger openings in the MS; however, natural regeneration of the small openings (15 m) may be slow in the MS.

5. The extended rotation time and long cutting cycles being used in these silvicultural systems could make the use of natural regeneration economically feasible.

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